Hydrostatic and Nonhydrostatic Nested Modeling of Straits in the Philippines Archipelago

Dr. Patrick C. Gallacher
Naval Research Laboratory, Ocean Sciences Branch
Stennis Space Center, MS 39529
phone: (228) 688-5315; fax: (228) 688-4149; e-mail: gallacher@nrlssc.navy.mil

Award Number “N00014-10-WX20784”

LONG-TERM GOALS

This study utilizes nested nonhydrostatic models embedded in hydrostatic models to simulate and predict the submesoscale dynamics of straits at high spatial and temporal resolutions. The goal of this work is to understand the submesoscale dynamics of straits and the impact of these dynamics on the throughflow in the straits. The Navy requires the ability to forecast features and circulations forced by these dynamics on scales that impact naval operations, i.e. kilometers to meters.

OBJECTIVES

The primary objective is to understand the submesoscale dynamics in straits using nested nonhydrostatic models embedded in hydrostatic models. Specifically we will work

- To understand the effects and interactions of the primary forcing components:
    - Tides, especially the spring-neap tidal cycle and remotely versus locally generated tides,
    - Large scale circulation, particularly the Pacific to Indian ocean throughflow and it’s seasonal variability,
    - Winds, especially the Southeast Asian monsoon cycle,
- To establish the resolution (dx and dz) and the aspect ratio (dx/dz) required to accurately simulate submesoscale physics and structures,
- To determine the importance of accurate and detailed representation of topography and forcing, especially at open boundaries,
- To understand the impact of rotation on the flow in straits, this is particularly important to nonhydrostatic physics,
- To explore the impact of data assimilation in a nonhydrostatic model, especially for sparse and irregular data,
- To compare model and field observations both for planning and for assessment.

APPROACH

We use a system of multiply nested nonhydrostatic model (NRL-MIT) domains which utilize hydrostatic models (NCOM and/or HYCOM) to provide open boundary conditions for the coarsest NRL-MIT domain. The NRL-MIT domains consist of the nonhydrostatic version of the MITgcm

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2010**	2. REPORT TYPE	3. DATES COVERED **00-00-2010 to 00-00-2010**

4. TITLE AND SUBTITLE **Hydrostatic and Nonhydrostatic Nested Modeling of Straits in the Philippines Archipelago**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,Ocean Sciences Branch,Stennis Space Center,MS,39529**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**7**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

model wrapped in a suite of scripts that provide initial/restart fields, open boundary values and handle output in a series of segmented, parallel integrations that maximize cpu usage and the ratio of system to wall clock time. The forcing consists of surface fluxes from the NOGAPS and COAMPS operational nowcast/forecast systems and open boundary conditions from the NCOM and/or HYCOM nowcast/forecast systems. HYCOM forecasts with resolutions of up to 4 km may be available in the region in the next year or two (Harley Hurlburt, personal communication). The basic bathymetry will be the NRL DBDB2 (2 minute) bathymetry which we hope will be enhanced and improved with several additional bathymetry databases obtained during the DRI.

WORK COMPLETED

A NRL-MIT model domain has been defined for the Apo Reef – Panay Sill (ARPS200) region (Figure 1). The domain is a rotated spherical polar grid rotated -44° from east to coincide with the orientation of the Mindoro Straits. The domain is 300 km (along the strait) by 150 km (across the strait) with a nominal resolution of 1/200° or 500 m. The vertical grid is variable with a minimum dz of 10 m, a maximum dz of 81 m and a maximum depth of 1882 m. The model time step was 10 s.

This domain was particularly challenging due to the rotated grid and the extensive islands and the complex bathymetry. We also implemented a combined Transport Correction Scheme (TCS) boundary condition and Flow Relaxation Scheme (FRS) to prevent the solution from diverging due to small inconsistencies in the lateral fluxes.

We acquired NCOM data (Figure 2) from NRL/MTRY's 3 km forecast of January and February 2008. We hindcast the IOP period of 2/12/2008 – 2/27/2008. The domain contains 600 points along the strait and 300 points across the strait with 74 points in the vertical for a total of 13.3 million grid points. The hindcast used 144 processor elements and 330,0000 processor hours in 6 days of wall clock time.

RESULTS

Hindcasts of the 3D nonhydrostatic flow through the Mindoro straits at 500m resolution are forced with data from NRL-MTRY's RELO COAMPS. The model data are compared with mooring data in the Mindoro straits and the Panay Straits. The results are in good agreement in the Mindoro straits (Figure 3). However, in the Panay straits differences in model and in situ bathymetries caused significant discrepancies in the comparisons (Figure 4). Work is ongoing to improve the bathymetry and the open boundary conditions and to verify the rotated values.

IMPACT/APPLICATIONS

Tactical scale or submesoscale forecasting in domains of 100 to 200 km will require nonhydrostatic modeling systems with resolutions of 100s of meters or less to correctly predict the NLIWs, turbulent regions, fronts, boils and small scale eddies. This project studies the dynamics of NLIWs, their interactions and their impact on the tactical environment. This work furthers the basic understanding of NLIWs and lays the foundation for fututre nonhydrostatic forecast systems.

RELATED PROJECTS

This project is synergistic with the following projects:
Internal Waves in Straits (IWISE) ONR DRI,
Effects of Non-Acoustic Noise on Multi-Sensor USW Networks, NRL 6.2 core

—This work is supported by the HPC project
Nonhydrostatic Modeling of Nonlinear Internal Waves and Turbulence

PUBLICATIONS

Schaferkotter, M. R., P. C. Gallacher, D. A. Hebert, Submesoscale Flow and Dynamics in the Mindoro Straits , Ocean Sciences Meeting, Jan. 2010.

Gallacher, P. C., J. Sprintall, D. A. Hebert, M. R. Schaferkotter, Submesoscale Transports and Dynamics in the Mindoro Straits, Western Pacific Geophysical Meeting, June 2010.

Gallacher, P. C., J. Sprintall, D. A. Hebert, M. R. Schaferkotter, Submesoscale Transports and Dynamics in the Mindoro Straits, Western Pacific Geophysical Meeting, June 2010.

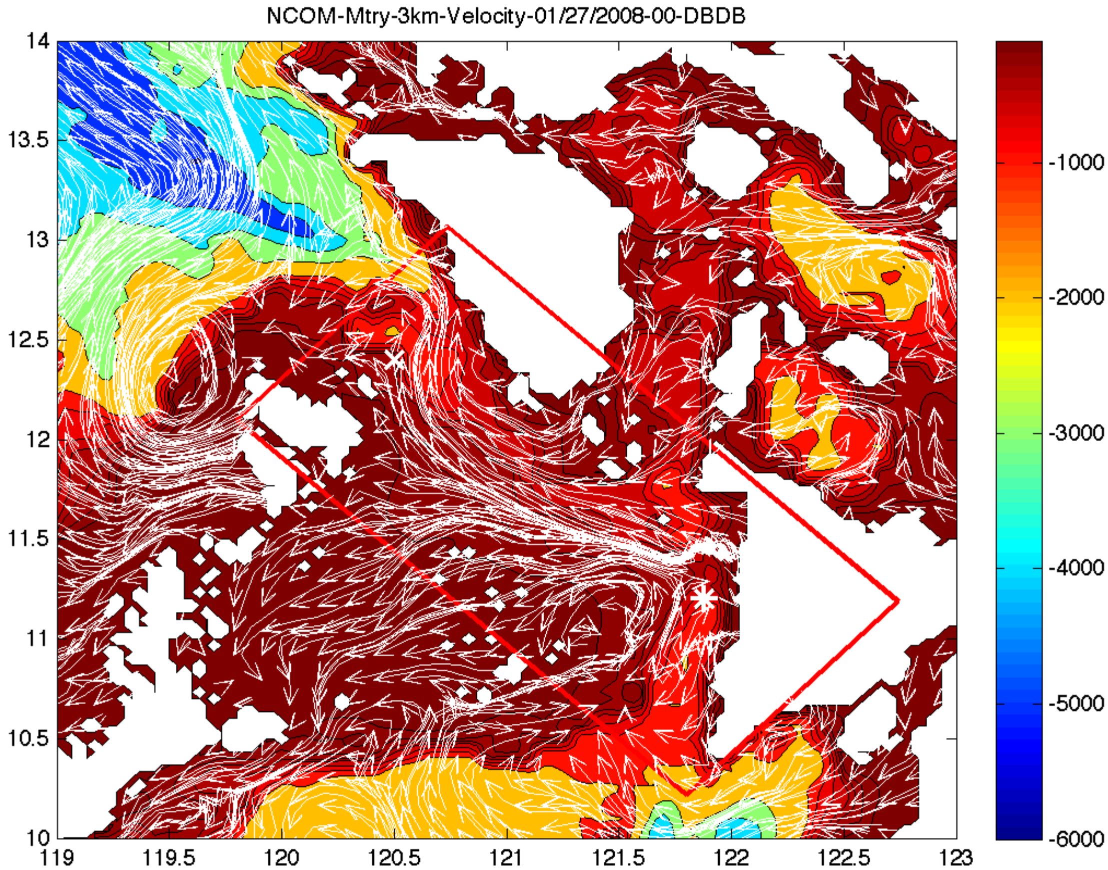

Figure 1. Surface velocity from the relocatable NCOM/COAMPS model for 0000Z January 27, 2008. Color contours are depth. The MIT domain is overlayed in red

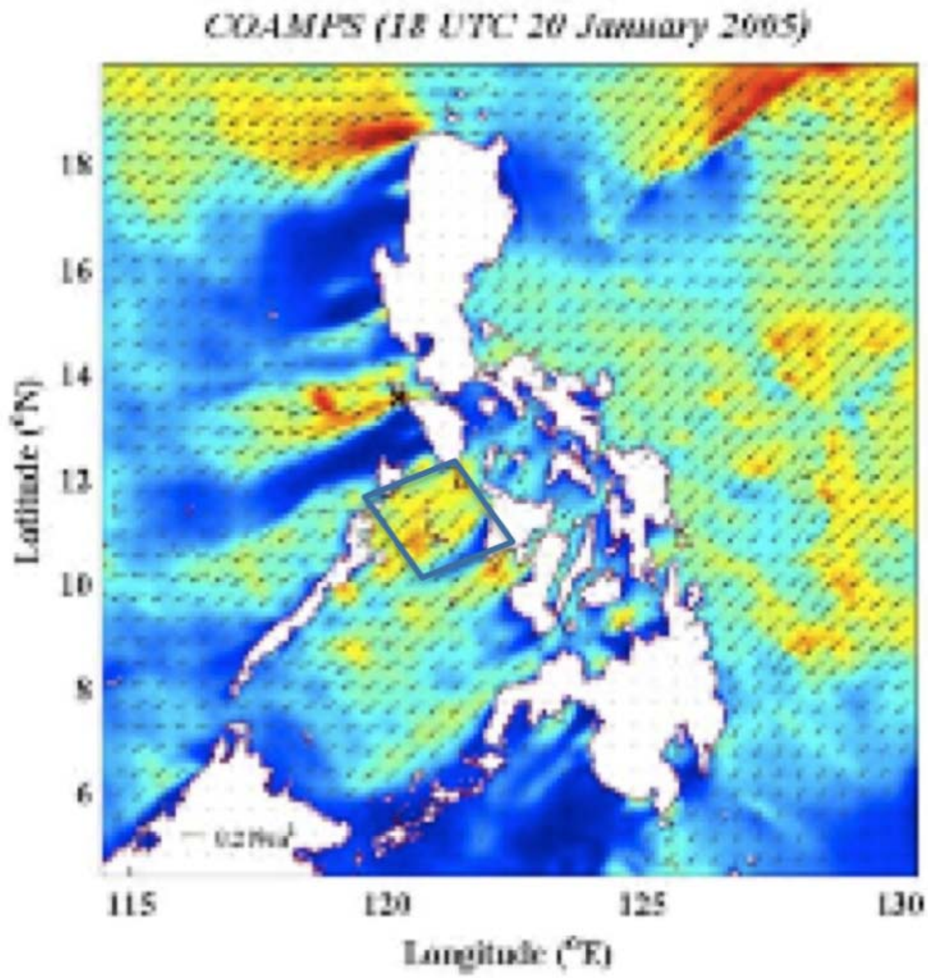

Figure 2. COAMPS domain with NRL-MIT model shown in the blue box.

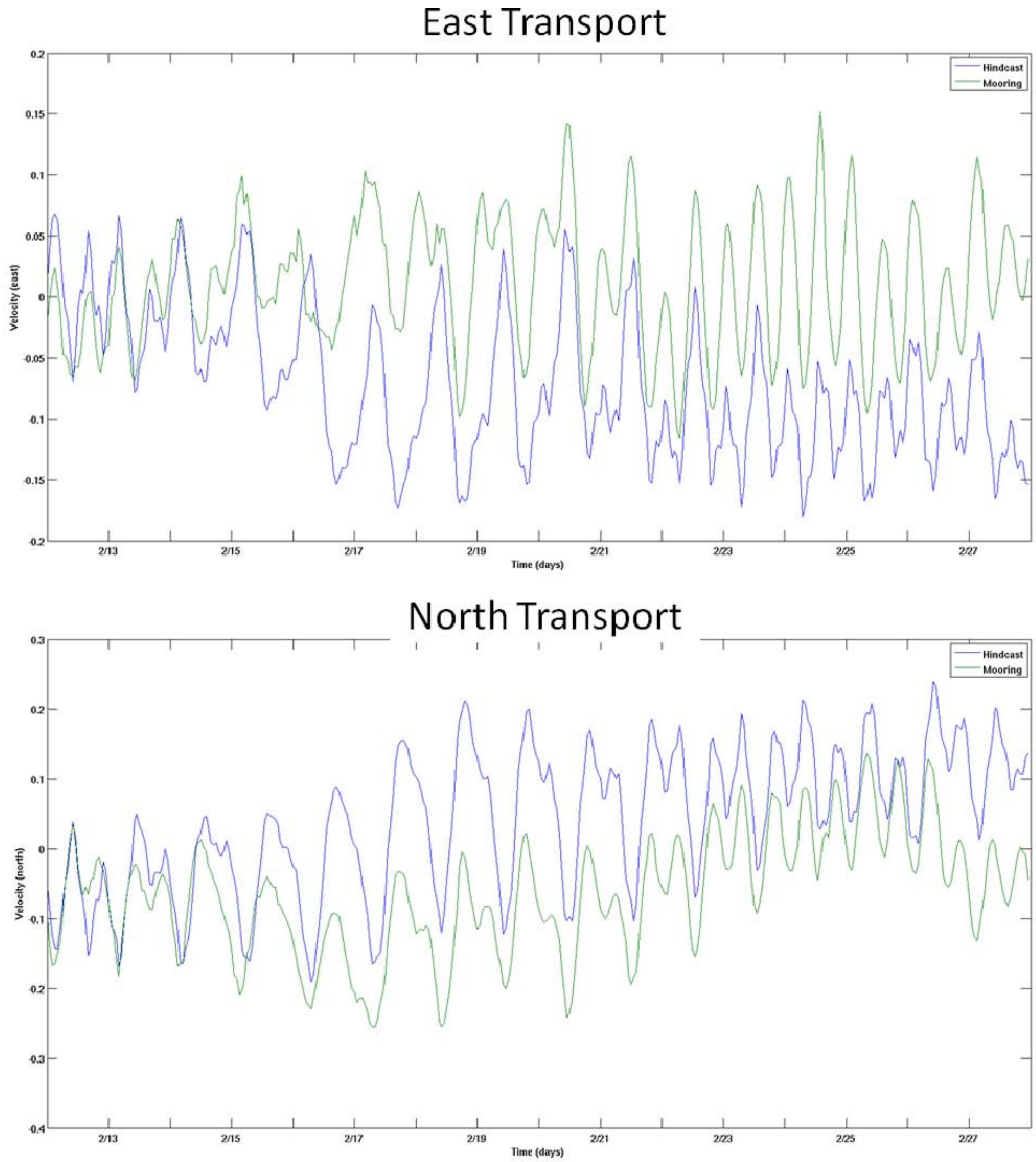

Figure 3. Transport at Mindoro mooring.
Model and in situ data are in reasonable agreement.

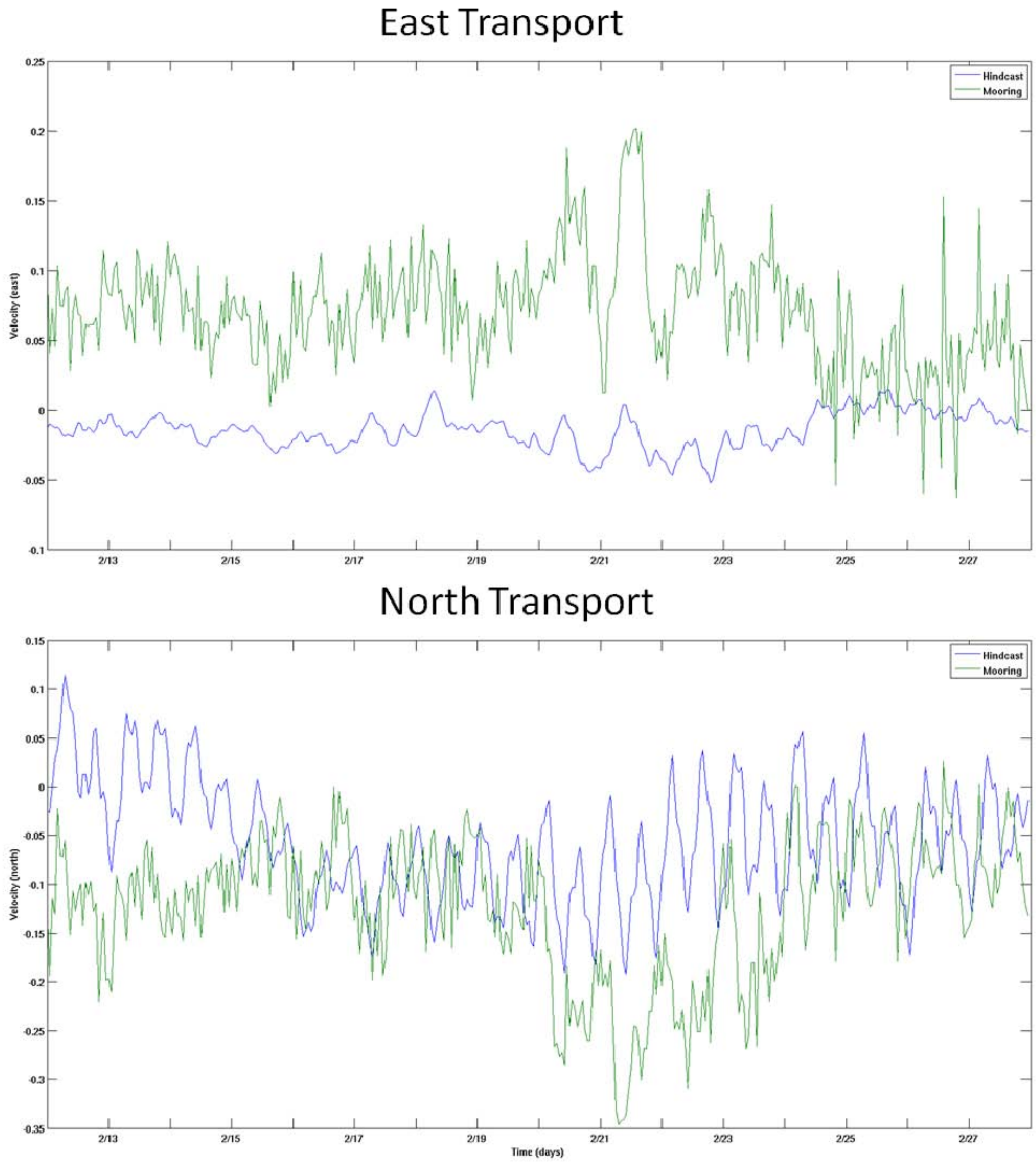

Figure 4. Transport at Panay mooring. Model and in situ data do not agree well due in part to significant discrepancies between model and mooring bathymetry.